

# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-373682

(43)Date of publication of application : 26.12.2002

(51)Int.Cl.

H01M 8/04  
H01M 8/10

(21)Application number : 2001-181524

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(22)Date of filing : 15.06.2001

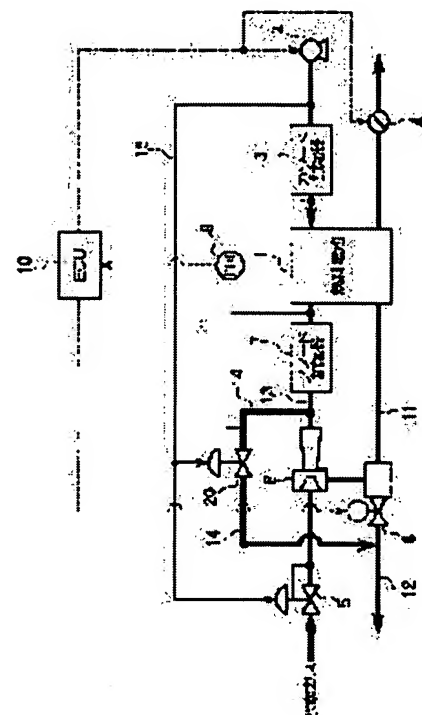
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## (54) FUEL CELL SYSTEM

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To ensure interpolar differential pressure control, in a solid polymer electrolyte membrane fuel cell.

**SOLUTION:** This fuel cell system comprises the fuel cell 1, having an anode electrode and a cathode electrode on the opposite sides of a solid polymer electrolyte membrane to generate power, when gaseous hydrogen is supplied to the anode electrode and air is supplied to the cathode electrode, a regulator 5 for reducing the pressure of the gaseous hydrogen supplied to the fuel cell 1 according to the pressure of the air, and a purge valve 8, disposed in a hydrogen off-gas recovery line 11 as a passage of gaseous hydrogen discharged from the fuel cell 1 and adapted to open, according to a differential pressure between both electrodes to release the pressure of hydrogen off-gas; and further comprises, on downstream side of the regulator 5, an interpolar differential pressure control valve 20 for controlling the differential pressure between both electrodes by releasing the gaseous hydrogen via valve travel control, according to thrust difference caused, when a first thrust based on the pressure of the air and urging force of a bias setting spring and a second thrust, based on the pressure of the gaseous hydrogen are brought in opposed action.



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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the electrode-differential-pressure control technique in the fuel cell of a solid-state polyelectrolyte membrane type.

[0002]

[Description of the Prior Art] The both sides of the solid-state polyelectrolyte film are equipped with an anode electrode and a cathode electrode, fuel gas (for example, hydrogen gas) is supplied to an anode electrode, oxidizer gas (for example, oxygen or air) is supplied to a cathode electrode, and there are some which extracted the chemical energy concerning the oxidation reduction reaction of these gas as direct electrical energy in the fuel cell carried in a fuel cell powered vehicle etc. In this fuel cell, hydrogen gas ionizes by the anode side and it moves in the inside of a solid-state polyelectrolyte, and an electron can move to a cathode side through an external load, and can take out now the electrical energy by a series of electrochemical reaction which reacts with oxygen and generates water.

[0003] An example of the conventional fuel cell system equipped with this fuel cell is shown in drawing 5. In this fuel cell system, the pressure up of the air as oxidizer gas is carried out to a predetermined pressure by the compressor 52, it humidifies with the cathode humidifier 53, and the cathode electrode of a fuel cell 51 is supplied. After a generation of electrical energy is presented, this air is discharged as air off-gas from a fuel cell 1, and is discharged through a pressure control valve 54. This pressure control valve 54 controls the supply pressure of the air in a cathode electrode. On the other hand, the hydrogen gas as fuel gas is decompressed with a regulator 55, it humidifies with the anode humidifier 57 via an ejector 56, and the anode electrode of a fuel cell 1 is supplied. Here, a regulator 55 decreases the pressure of the hydrogen gas supplied to an anode electrode according to the pressure of the air supplied to a cathode electrode. After a generation of electrical energy is presented with hydrogen gas, it is discharged as hydrogen off-gas from a fuel cell 1, is attracted by the ejector through the hydrogen off-gas recovery way 61, joins the fresh hydrogen gas which passed the regulator, and is again supplied to the anode electrode of a fuel cell 1.

[0004] By the way, in order to avoid breakage of the solid-state polyelectrolyte film, it is necessary to hold down the differential pressure of the pressure of the hydrogen gas of an anode electrode, and the pressure of the air of a cathode electrode to below predetermined default value, and to operate in this fuel cell system. then, the former -- the hydrogen off-gas recovery way 61 -- electromagnetism -- the purge valve 58 of a drive type was formed, and when said differential pressure reached said default value, the purge valve 58 was controlled electrically to make a purge valve 58 open. The technique same also to JP,7-78624,A as this is indicated. In addition, a purge valve 58 is suitably opened if needed, when draining the water of condensation with which the moisture contained in hydrogen off-gas condenses, and it it not only opens for said differential pressure control, but is generated.

[0005]

[Problem(s) to be Solved by the Invention] However, when closing motion of a purge valve 58 is electrically controlled like before, the differential pressure between said two poles is controlled and fault arises fracture of an electrical signal line, the fall of power, or on a computer, a purge valve 58 stops operating, and there is a possibility of performing unnecessary valve opening and reducing system efficiency.

[0006] Moreover, replacing with the electrode-differential-pressure management using said purge valve, and missing an excessive pressure mechanically by the maximum pressure control using a spring type pop off valve is also considered. Here, a spring type pop off valve is a mechanical relief valve which has the structure which the spring load is beforehand set up so that it may open with the maximum specified-pressure value, the valve element currently pressed down by the clausilium condition according to the spring load when the pressure exceeded default value opens, and misses a pressure. This spring type pop off valve can set the maximum specified pressure which is a valve-opening threshold only to the pressure value (1 constant pressure) of one point somewhere.

[0007] However, in the case of a fuel cell, as shown in drawing 6, according to the output value of a fuel cell, the upper limit of pressure of an anode electrode changes. Therefore, it is the spring type pop off valve to which only one point can set a valve-opening threshold (the maximum specified-pressure value), and is substantially [ that it is difficult to manage the maximum pressure of the anode electrode of a fuel cell, and ] impossible. Then, this invention can ensure management of electrode differential pressure, even if the upper-limit-of-pressure force of reactant gas changes according to the output value of a fuel cell, and it offers the fuel cell system which can ensure breakage prevention of the solid-state polyelectrolyte film.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, invention indicated to claim 1 It has an anode electrode and a cathode electrode on both sides of the solid-state polyelectrolyte film. To an anode electrode Fuel gas The fuel cell which (for example, the hydrogen gas in the gestalt of operation mentioned later) is supplied, and oxidizer gas (for example, air in the gestalt of operation mentioned later) is supplied to a cathode electrode, and is generated (for example, fuel cell 1 in the gestalt of operation mentioned later), Either gas of said fuel gas supplied to said fuel cell, and oxidizer gas The regulator which decreases the pressure of (the hydrogen gas [ for example, ] in the gestalt of operation mentioned later) according to the pressure of the gas (for example, air in the gestalt of operation mentioned later) of another side (for example, regulator 5 in the gestalt of operation mentioned later), The passage of the off-gas of one [ which is discharged from said fuel cell / said ] gas The purge valve which is prepared in (for example, the hydrogen off-gas recovery way 11 in the gestalt of operation mentioned later), opens according to the differential pressure between said two electrodes, and misses the pressure of said off-gas (for example, purge valve 8 in the gestalt of operation mentioned later), In a preparation \*\*\*\*\* system The pressure and elastic body of gas of said another side (For example) When it counters mutually and the 1st thrust based on the energization force of the spring 29 for a bias setup in the gestalt of operation mentioned later and the 2nd thrust based on the pressure of one [ said ] gas are made to act It is characterized by equipping the lower stream of a river of said regulator with the differential pressure control valve between poles (for example, differential pressure control valve 20 between poles in the gestalt of operation mentioned later) which is alike, adjusts whenever [ valve-opening ] according to the thrust difference to produce, misses one [ said ] gas and adjusts the differential pressure between said two electrodes.

[0009] Thus, even if the pressure of the oxidizer gas supplied to the pressure or cathode electrode of fuel gas supplied to an anode electrode by constituting changes according to the output of a fuel cell, the differential pressure between two electrodes (henceforth electrode differential pressure) is controllable by both the purge valve, and both [ either or ] between poles. Said thrust difference also becomes large, so that the differential pressure of the pressure of one [ said ] gas and the pressure of the gas of another side is large, and the differential pressure control valve between poles adjusts whenever [ valve-opening ] so that it may become small, and enlarges electrode differential pressure, so that whenever [ valve-opening ] is adjusted so that it may become large, electrode differential pressure is made small, so that said thrust difference is large, and said thrust difference is small in the differential pressure control valve between poles especially. Consequently, it enables the differential pressure control valve between poles to adjust electrode differential pressure to the predetermined range. Moreover, since actuation of the differential pressure control valve between poles is purely mechanical, also when an electric trouble arises to a system, it operates normally.

[0010] Differential pressure between the two electrodes whose invention indicated to claim 2 is the valve-opening thresholds of said purge valve in invention according to claim 1 is characterized by being set up smaller than the differential pressure between the two electrodes which are the valve-opening thresholds of said differential pressure control valve. Thus, when management of the electrode differential pressure at the time of normal operation is performed by actuation of a purge valve with a small valve-opening threshold and electrode differential pressure becomes size from the valve-opening threshold of the differential pressure control valve between poles by constituting, both a purge valve and the differential pressure control valve between poles open, and electrode differential pressure is reduced more quickly. Moreover, also when a purge valve causes poor actuation, the differential pressure control valve between poles should operate, and breakage of the solid-state polyelectrolyte film should be prevented.

[0011] Invention indicated in claim 3 term is set to invention according to claim 1 or 2. Said purge valve and the differential pressure control valve between said poles are constituted by one. One valve element (For example, the valve element 27 in the gestalt of operation mentioned later) shares the valve element of said purge valve, and the valve element of the differential pressure control valve between said poles. This valve element By the mechanical component (for example, the plunger 35 in the gestalt of operation mentioned later, the coil 37 for solenoids) of said purge valve which makes an electric signal drive timing, while a switching action is possible It is characterized by being the septa coordinated with said valve element, and being able to adjust the septum (for example, pressure regulation diaphragm 22 in the gestalt of operation mentioned later) which said the 1st thrust and said 2nd thrust counter the both sides, and acts on them whenever [ valve-opening ] as a mechanical component of the differential pressure

control valve between said poles. Thus, by constituting, reduction of components mark and reduction of an installation tooth space can be aimed at.

[0012]

[Embodiment of the Invention] Hereafter, the gestalt of operation of the fuel cell system concerning this invention is explained with reference to the drawing of drawing 4 from drawing 1. In addition, the fuel cell system in the gestalt of each following operation is the mode carried in the fuel cell powered vehicle.

[0013] [Gestalt of the 1st operation] First, the gestalt of operation of the 1st of the fuel cell system concerning this invention is explained with reference to the drawing of drawing 3 from drawing 1. Drawing 1 is the outline block diagram of a fuel cell system. A fuel cell 1 carries out the laminating of many cels in which it comes to prepare the gas passageway for an anode electrode and a cathode electrode being prepared in the both sides of the solid-state polyelectrolyte film, and supplying reactant gas to the outside of each electrode, and is constituted. The hydrogen gas as fuel gas is supplied to an anode electrode, and this fuel cell 1 generates electricity by supplying the air as oxidizer gas to a cathode electrode.

[0014] After having been pressurized by the air compressor 2, being humidified with the cathode humidifier 3, supplying the cathode electrode of a fuel cell 1 and offering the oxygen in this air as an oxidizer, air is discharged as air off-gas from a fuel cell 1, and is emitted to atmospheric air through a pressure control valve 4. ECU10 controls a pressure control valve 4, and adjusts the supply pressure of the air in a cathode electrode to the pressure according to the demand output of a fuel cell 1 while it drives an air compressor 2 and supplies the air of the specified quantity to a fuel cell 1 according to the output (henceforth, demand output) demanded of the fuel cell 1.

[0015] After the hydrogen gas emitted from the high-pressure hydrogen tank which is not illustrated on the other hand is decompressed by the regulator 5, it passes along an ejector 6, is humidified with the anode humidifier 7, and is supplied to the anode electrode of a fuel cell 1. After a generation of electrical energy is presented, this hydrogen gas is discharged as hydrogen off-gas from a fuel cell 1, is attracted by the ejector 6 through the hydrogen off-gas recovery way 11, joins the hydrogen gas supplied from said high-pressure hydrogen tank, and is again supplied to a fuel cell 1, and it circulates through it.

[0016] By making into signal pressure the pressure of the air supplied from an air compressor 2, a regulator 5 consists of a proportionality pressure control valve of for example, an air type, it is inputted through the pneumatic-signal installation way 15, and it carries out reduced pressure control so that the pressure of the hydrogen gas of regulator 5 outlet may serve as a predetermined pressure range according to said signal pressure. In addition, a regulator 5 is controlled by the fuel cell system in the gestalt of this operation so that the pressure ("anode pole gas pressure" is called hereafter) of the hydrogen gas supplied to an anode electrode becomes larger than the pressure ("cathode pole gas pressure" is called hereafter) of the air supplied to a cathode electrode.

[0017] the hydrogen off-gas recovery way 11 -- electromagnetism -- it connects with the hydrogen off-gas exhaust passage 12 through the purge valve 8 of a drive type. the output of the differential pressure sensor 9 by which ECU10 detects the differential pressure of anode pole gas pressure and cathode pole gas pressure, i.e., electrode differential pressure, -- being based -- the electromagnetism of a purge valve 8 -- a mechanical component is operated and closing motion control is performed. namely, the electromagnetism of a purge valve 8 -- the mechanical component makes the electric signal drive timing. This purge valve 8 opens, when the output value of the differential pressure sensor 9 amounts to  $\Delta P_1$ , it controls electrode differential pressure or less to  $\Delta P_1$ , and also when predetermined conditions are fulfilled, it opens, and it has an operation of draining so that water may not collect on the anode electrode side of a fuel cell 1.

[0018] The hydrogen supply way 13 which connects the anode humidifier 7 with an ejector 6 is connected to the hydrogen off-gas exhaust passage 12 through the hydrogen gas exhaust passage 14 equipped with the differential pressure control valve 20 between poles which has the characteristic configuration of this invention. The differential pressure control valve 20 between this pole is explained with reference to the outline sectional view of drawing 2. The building envelope of the body 21 of the electrode-differential-pressure regulator valve 20 is divided up and down by the pressure regulation diaphragm 22, the space above diaphragm 22 has become the signal pressure room 23, and lower space has become the hydrogen gas passageway 24. The signal pressure room 23 is the closed space equipped with the air installation hole 25, and the air pressurized by the compressor 2 is introduced into the signal pressure room 23 from the air installation hole 25 through the pneumatic-signal installation way 15.

[0019] The stem 26 is attached in the inferior surface of tongue of diaphragm 22, and the valve element 27 in which taking-a-seat estrangement is possible is formed in the stem 26 from the bottom to the valve-seat section 28 in the hydrogen gas passageway 24. And the spring 29 for a bias setup (elastic body) which energizes a valve element 27 in the direction which sits down in the valve-seat section 28 is formed in the signal pressure room 23.

[0020] Moreover, the hydrogen gas inlet 31 which is open for free passage to hydrogen gas-passageway 24a of the side

by which the valve element 27 is arranged, and the hydrogen gas outlet 32 which is open for free passage to hydrogen gas-passageway 24b of the side by which the valve element 27 is not arranged are formed, the hydrogen gas inlet 31 is connected to the hydrogen supply pipe 13 through the hydrogen gas exhaust passage 14, and the hydrogen gas outlet 32 is connected to the body 21 through the hydrogen gas exhaust passage 14 in the hydrogen off-gas exhaust passage 12. Therefore, as shown in drawing 1 and drawing 2, the hydrogen gas decompressed with the ejector 6 is introduced into hydrogen gas-passageway 24a from the hydrogen gas inlet 31, and if a valve element 27 estranges and opens from the valve-seat section 28, the hydrogen gas introduced into hydrogen gas-passageway 24a will flow into hydrogen gas-passageway 24b, and will come to flow from the hydrogen gas outlet 32 to the hydrogen off-gas exhaust passage 12 further.

[0021] In addition, it is desirable to use what was excellent in the corrosion resistance over hydrogen about the components referring to [ the components which constitute the differential pressure control valve 20 between poles ] hydrogen gas, for example, the aluminum which performed stainless steel or surface alumite processing to the body 21, the valve element 27, and the stem 26 is suitable, and a fluororubber is suitable for diaphragm 22.

[0022] Thus, in the constituted differential pressure control valve 20 between poles, as a result of the pressure of the air in the signal pressure room 23 and the energization force of a spring 29 acting on the top face of diaphragm 22, the 1st thrust based on these acts on the top face of diaphragm 22 downward, and on the other hand, as a result of the pressure of the hydrogen gas in hydrogen gas-passageway 24a acting on the inferior surface of tongue of diaphragm 22, the 2nd thrust based on this acts on the inferior surface of tongue of diaphragm 22 upward. And diaphragm 22 will be governed by the thrust difference of these 1st thrusts and the 2nd thrust, and will move. Namely, when the 2nd thrust is smaller than the 1st thrust, the downward force acts on diaphragm 22, it pushes in the direction (namely, the direction of clausilium) which makes a valve element 27 approach the valve-seat section 28, when the 2nd thrust becomes larger than the 1st thrust, the upward force acts on diaphragm 22, and it pushes in the direction (namely, the valve-opening direction) which makes a valve element 27 estrange from the valve-seat section 28.

[0023] By the way, the pressure of the hydrogen gas with which the pressure of the air supplied to the signal pressure room 23 is this \*\* mostly, and is supplied to hydrogen gas-passageway 24a with cathode pole gas pressure is this \*\* mostly with anode pole gas pressure. Therefore, the differential pressure control valve 20 between poles can be said to be the regulator valve which adjusts whenever [ valve-opening ] according to the thrust difference produced when the 1st thrust based on cathode pole gas pressure and the energization force of a spring 29 and the 2nd thrust based on anode pole gas pressure are made to act on both sides of diaphragm 22 face to face.

[0024] And in the differential pressure control valve 10 between poles of the gestalt of this operation, it sets up as the spring 29 is compressed in the state of clausilium (setting up so that the energization force of a spring 29 may act on diaphragm 22 in a clausilium condition if it puts in another way), and the pressure corresponding to the energization force of the spring 29 in a clausilium condition is set as the upper limit Plim of electrode differential pressure. Thus, since the 1st thrust will serve as size from the 2nd thrust when electrode differential pressure is below Plim if it sets up Since the 2nd thrust serves as size from the 1st thrust when the clausilium condition to which the valve element 27 sat down in the valve-seat section 28 is held and electrode differential pressure exceeds a upper limit Plim A valve element 27 estranges and opens from the valve-seat section 28, and the hydrogen gas in hydrogen gas-passageway 24a is missed to the hydrogen off-gas exhaust passage 12, and it acts so that electrode differential pressure may be decreased. And a valve element 27 moves in the direction of clausilium with reduction in electrode differential pressure, and if electrode differential pressure becomes below the upper limit Plim, a valve element 27 will sit down and close the valve in the valve-seat section 28. In addition, a degree type is materialized between the energization force F of the spring 29 in a clausilium condition, the upper limit Plim of electrode differential pressure, and the area S of diaphragm 22.

$F = Plim \cdot S$  [0025] Moreover, in the gestalt of this operation, the differential pressure value  $\Delta P_1$  which is a valve-opening threshold of a purge valve 8 is set up smaller than the upper limit Plim which is a valve-opening threshold of the differential pressure control valve 20 between poles. If it does in this way, management of electrode differential pressure is performed by the purge valve 8 with a small valve-opening threshold at the time of normal operation, and a fuel cell 1 can be maintained to good operational status. And when electrode differential pressure becomes size from the valve-opening threshold of the differential pressure control valve 20 between poles, in addition to a purge valve 8, both differential pressure control valves 20 between poles can open, electrode differential pressure can be reduced quickly, and breakage of the solid-state polyelectrolyte film can be prevented certainly.

[0026] furthermore, since the differential pressure control valve 20 between poles operate mechanically purely, also when a purge valve 8 should cause poor actuation by the electric troubles on a system ( for example, fracture of the electrical signal line to a purge valve 8, the trouble on lowering of electric power and a computer, etc. ) etc., the differential pressure control valve 20 between poles operate certainly, prevent breakage of the solid-state



polyelectrolyte film, and be extremely excellent in respect of fail-safe. Moreover, the pressure control in this fuel cell system. The maximum pressure of anode pole gas pressure is not managed using the spring type pop off valve to which only one point can set a valve-opening threshold. Since electrode differential pressure is managed by both the purge valve 8, and both [ either or ] 20 between poles. Even if anode pole gas pressure or cathode pole gas pressure changes according to the output of a fuel cell 1, when managing electrode differential pressure, it is almost uninfluential, therefore breakage of the solid-state polyelectrolyte film can be prevented certainly.

[0027] Drawing 3 is the modification which changed the installation location of the differential pressure control valve 20 between poles. That is, in the example of drawing 3, the differential pressure control valve 20 between poles is formed in the hydrogen off-gas exhaust passage 16 which connects the hydrogen off-gas recovery way 11 and the hydrogen off-gas exhaust passage 12. And the hydrogen off-gas which flows the hydrogen off-gas recovery way 11 is introduced into hydrogen gas-passageway 24a through the hydrogen off-gas way 16 from the hydrogen gas inlet 31 of the differential pressure control valve 20 between poles of drawing 2. Furthermore, the air pressurized by the compressor 2 is introduced into the signal pressure room 23 from the air installation hole 25 through the pneumatic-signal installation way 17. Thus, also by the installed differential pressure control valve 20 between poles, when electrode differential pressure exceeds  $P_{lim}$ , the differential pressure control valve 20 between poles can open, electrode differential pressure can be decreased, and the same operation and effectiveness as the thing of the mode of drawing 1 can be acquired.

[0028] [Gestalt of the 2nd operation] Drawing 4 shows the example which unified the purge valve 8 and the differential pressure control valve 20 between poles. In addition, suppose for convenience that the whole valve unified here is called the differential pressure control valve 20 between poles. Also in the case of the differential pressure control valve 20 between this pole, it has the body 21, the pressure regulation diaphragm (septum) 22, the signal pressure room 23, the hydrogen gas passageways 24, 24a, and 24b, the air installation hole 25, a stem 26, a valve element 27, the valve-seat section 28, the spring 29 for a bias setup, the hydrogen gas inlet 31, and the hydrogen gas outlet 32. A valve element 27 is also a valve element of the differential pressure control valve between poles while being a valve element of a purge valve, therefore it is sharing the valve element 27. In the differential pressure control valve 20 between this pole, the stem 26 is prolonged also to the diaphragm 22 up side, the plunger 35 for purge valves (mechanical component of a purge valve) is formed in the upper limit of a stem 26, the plunger stowage 36 which contains a plunger 35 possible [ vertical movement ] is established in the body 21, and the coil 37 for solenoids for moving a plunger 35 vertically (mechanical component of a purge valve) is formed in the outside of the plunger stowage 36.

[0029] When making it function as a purge valve 8 which mentioned above the differential pressure control valve 20 between this pole, by passing a current in the coil for solenoids, considering as an electromagnet, resisting the energization force of a spring 29 and pulling up a plunger 35 up, a valve element 27 is made to estrange from the valve-seat section 28, and it opens. That is, the switching action of the valve element 27 as a purge valve is carried out by the mechanical component (a plunger 35, coil 37 for solenoids) which makes an electric signal drive timing.

[0030] Moreover, the 2nd thrust based on the 1st thrust based on the pressure of the air in the signal pressure room 23 and the energization force of a spring 29 and the pressure of the hydrogen gas in hydrogen gas-passageway 24a is acting on the septum 22 coordinated with a valve element 27 through a stem 26 face to face, and this septum 22 has the function as a mechanical component (mechanical component of the differential pressure control valve between poles) which adjusts whenever [ valve-opening / of a valve element 27 ]. Namely, the situation where normal actuation as a purge valve is not performed by some electric troubles (for example, fracture, lowering of electric power, etc. of an electrical signal line) etc. arises. When electrode differential pressure exceeds an upper limit  $P_{lim}$ . Since said 2nd thrust serves as size from said 1st thrust, a valve element 27 estranges and opens from the valve-seat section 28, and the hydrogen gas in hydrogen gas-passageway 24a is missed to the hydrogen off-gas exhaust passage 12, and it acts so that electrode differential pressure may be decreased. And a valve element 27 moves in the direction of clausilium with reduction in electrode differential pressure, and if electrode differential pressure becomes below the upper limit  $P_{lim}$ , a valve element 27 will sit down and close the valve in the valve-seat section 28.

[0031] Thus, if a purge valve and the differential pressure control valve between poles are unified, since one structure-of-a-system component can be reduced and monopoly space can be reduced, in the fuel cell system for car loading which has a limitation in an installation tooth space, it becomes very advantageous.

[0032] Gestalt] of operation of others [ [ ] In addition, this invention is not restricted to the gestalt of operation mentioned above. For example, although the gestalt of operation mentioned above uses the pressure adjustment valve between poles for the electrode-differential-pressure adjustment in the fuel cell system which controls anode pole gas pressure more greatly than cathode pole gas pressure, it can also use the pressure adjustment valve 20 between poles for the electrode-differential-pressure adjustment in the fuel cell system which controls cathode pole gas pressure more

greatly than anode pole gas pressure.

[0033]

[Effect of the Invention] Even if the pressure of the oxidizer gas supplied to the pressure or cathode electrode of fuel gas supplied to an anode electrode changes according to the output of a fuel cell according to invention indicated to claim 1 so that it may explain above Since electrode differential pressure is controllable by both the purge valve, and both [ either or ] between poles While being able to maintain the good operational status of a fuel cell certainly, without reducing system efficiency, the outstanding effectiveness that breakage of the solid-state polyelectrolyte film can be prevented certainly is done so. Since especially the differential pressure control valve between poles adjusts electrode differential pressure to the range of desired by mechanical actuation purely, also when an electric trouble arises to a system, it operates normally, and is extremely excellent also in respect of fail-safe.

[0034] Since both a purge valve and the differential pressure control valve between poles open and electrode differential pressure is quickly reduced when according to invention indicated to claim 2 management of the electrode differential pressure at the time of normal operation can be performed by actuation of a purge valve with a small valve-opening threshold and electrode differential pressure becomes size from the valve-opening threshold of the differential pressure control valve between poles, breakage of the solid-state polyelectrolyte film can be prevented certainly. Moreover, since the differential pressure control valve between poles should operate and breakage of the solid-state polyelectrolyte film should be certainly prevented also when a purge valve causes poor actuation, it excels extremely also in respect of fail-safe. According to invention indicated to claim 3, it is effective in the ability to aim at reduction of components mark, and reduction of an installation tooth space.

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CLAIMS

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[Claim(s)]

[Claim 1] The fuel cell which it has an anode electrode and a cathode electrode on both sides of the solid-state polyelectrolyte film, fuel gas is supplied to an anode electrode, and oxidizer gas is supplied to a cathode electrode, and is generated The regulator which decreases the pressure of either gas of said fuel gas supplied to said fuel cell, and oxidizer gas according to the pressure of the gas of another side The purge valve which is prepared in the passage of the off-gas of one [ which is discharged from said fuel cell / said ] gas, opens according to the differential pressure between said two electrodes, and misses the pressure of said off-gas It is the fuel cell system equipped with the above. The differential pressure control valve between poles which adjusts whenever [ valve-opening ] according to the thrust difference produced when it counters mutually and the 1st thrust based on the pressure of the gas of said another side and the energization force of an elastic body and the 2nd thrust based on the pressure of one [ said ] gas are made to act, misses one [ said ] gas and adjusts the differential pressure between said two electrodes It is characterized by preparing for the lower stream of a river of said regulator.

[Claim 2] The differential pressure between the two electrodes which are the valve-opening thresholds of said purge valve is a fuel cell system according to claim 1 characterized by being set up smaller than the differential pressure between the two electrodes which are the valve-opening thresholds of said differential pressure control valve.

[Claim 3] Said purge valve and the differential pressure control valve between said poles are constituted by one, and one valve element shares the valve element of said purge valve, and the valve element of the differential pressure control valve between said poles. This valve element By the mechanical component of said purge valve which makes an electric signal drive timing, while a switching action is possible The fuel cell system according to claim 1 or 2 characterized by being the septa coordinated with said valve element, and being able to adjust the septum which said the 1st thrust and said 2nd thrust counter the both sides, and acts on them whenever [ valve-opening ] as a mechanical component of the differential pressure control valve between said poles.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is an outline block diagram in the gestalt of operation of the 1st of the fuel cell system concerning this invention.

[Drawing 2] It is the sectional view of the differential pressure control valve between poles used for the gestalt of said 1st operation.

[Drawing 3] It is an outline block diagram in the modification of the gestalt of said 1st operation.

[Drawing 4] It is the sectional view of the differential pressure control valve between poles in the gestalt of operation of the 2nd of the fuel cell system concerning this invention.

[Drawing 5] It is the outline block diagram showing an example of the conventional fuel cell system.

[Drawing 6] It is the graph which shows the relation between the output of a fuel cell, and a hydrogen pole upper limit.

[Description of Notations]

1 Fuel Cell

5 Regulator

8 Purge Valve

11 Hydrogen Off-gas Recovery Way (Passage of Off-gas of One Gas)

20 Differential Pressure Control Valve between Poles

22 Pressure Regulation Diaphragm (Septum)

27 Valve Element

29 Spring for Bias Setup (Elastic Body)

35 Plunger (Mechanical Component of Purge Valve)

37 Coil for Solenoids (Mechanical Component of Purge Valve)

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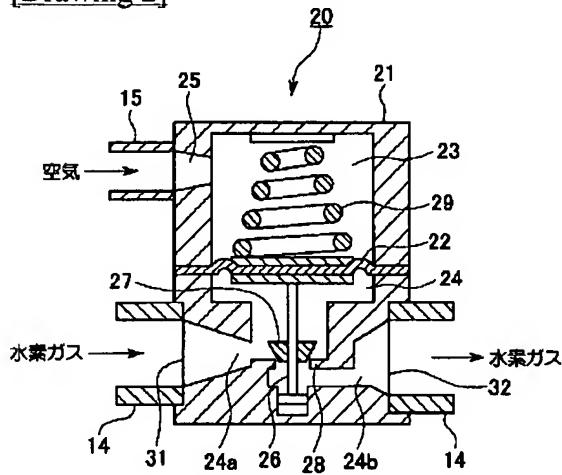
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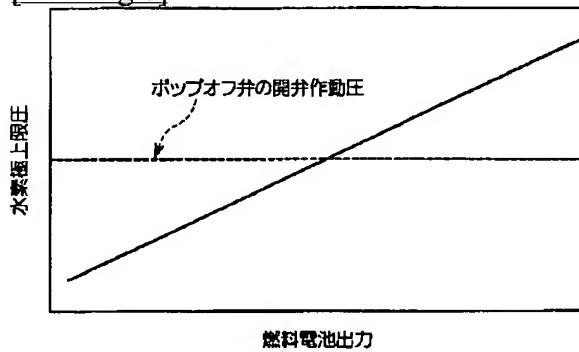
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2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

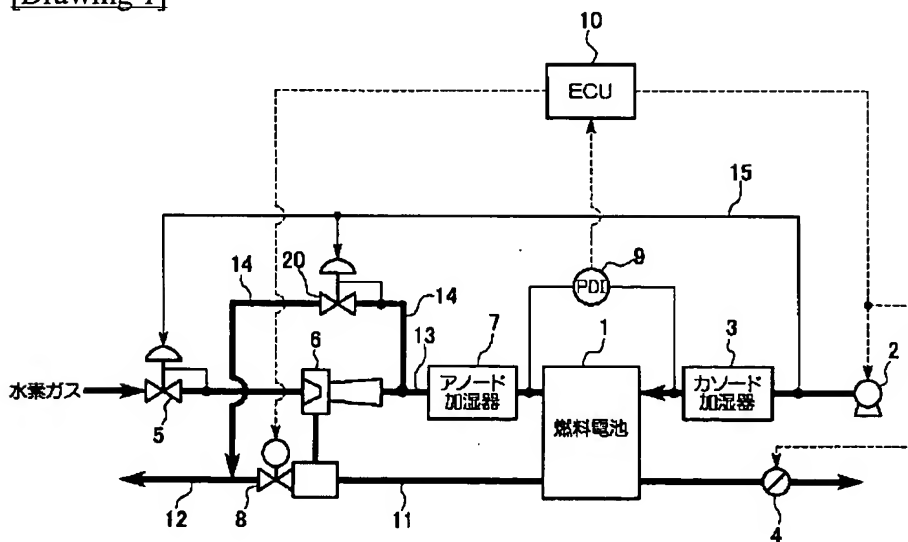
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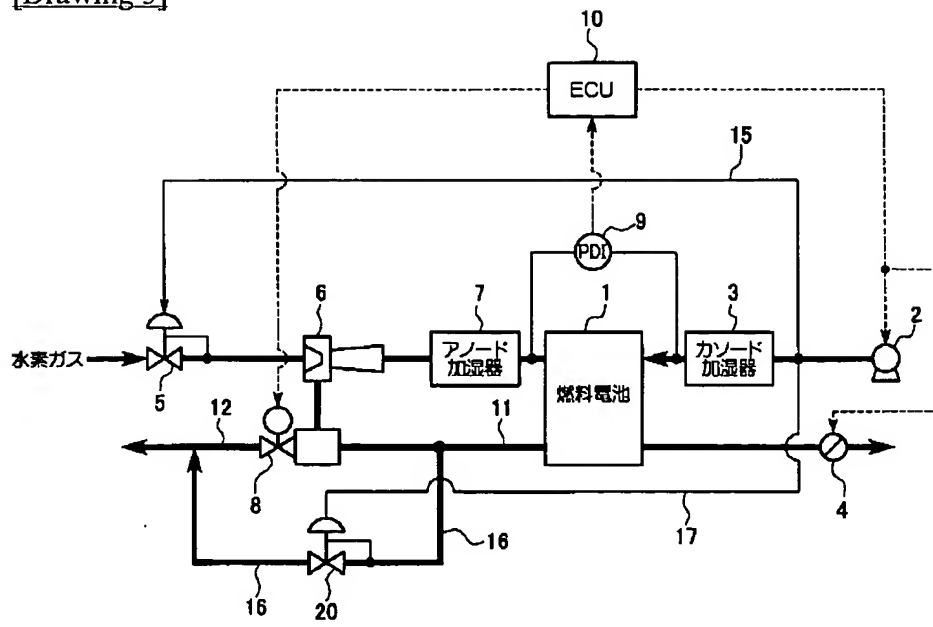
[Drawing 6]



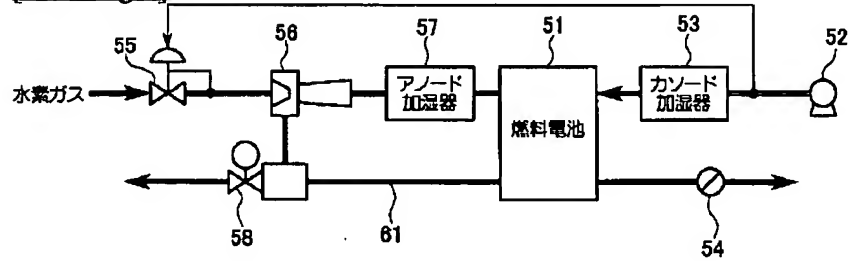
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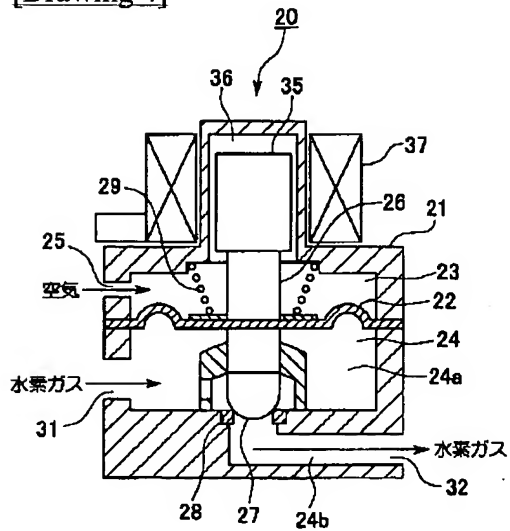
[Drawing 3]



[Drawing 5]



[Drawing 4]



[Translation done.]

## (書誌+要約+請求の範囲)

(19)【発行国】日本国特許庁(JP)  
 (12)【公報種別】公開特許公報(A)  
 (11)【公開番号】特開2002-373682(P2002-373682A)  
 (43)【公開日】平成14年12月26日(2002. 12. 26)  
 (54)【発明の名称】燃料電池システム  
 (51)【国際特許分類第7版】

H01M 8/04  
 8/10

## 【FI】

H01M 8/04 A  
 8/10

## 【審査請求】未請求

【請求項の数】3

【出願形態】OL

【全頁数】8

(21)【出願番号】特願2001-181524(P2001-181524)

(22)【出願日】平成13年6月15日(2001. 6. 15)

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【テーマコード(参考)】

5H026

5H027

## 【Fターム(参考)】

5H026 AA06

5H027 AA06 KK02 KK05 KK12 MM01 MM02

## (57)【要約】

【課題】固体高分子電解質膜型の燃料電池における極間差圧管理を確実にする。

【解決手段】固体高分子電解質膜の両側にアノード電極とカソード電極を有し、アノード電極に水素ガスが供給されカソード電極に空気が供給されて発電する燃料電池1と、燃料電池1に供給される水素ガスの圧力を空気の圧力に応じて減少させるレギュレータ5と、燃料電池1から排出される水素ガスの流路である水素オフガス回収路11に設けられ、前記両電極間の差圧に応じて開き水素オフガスの圧力を逃がすパージ弁8とを備え、さらに、空気の圧力およびバイアス設定用スプリングの付勢力に基づく第1の推力と水素ガスの圧力に基づく第2の推力とを互いに対向して作用させたときに生じる推力差に応じて弁開度調整を行い水素ガスを逃がして前記両電極間の差圧を調整する極間差圧調整弁20を、レギュレータ5の下流に備える。

## 【特許請求の範囲】

【請求項1】固体高分子電解質膜の両側にアノード電極とカソード電極を有し、アノード電極に燃料ガスが供給されカソード電極に酸化剤ガスが供給されて発電する燃料電池と、前記燃料電池に供給される前記燃料ガスと酸化剤ガスのいずれか一方のガスの圧力を他方のガスの圧力に応じて減少させるレギュレータと、前記燃料電池から排出される前記一方のガスのオフガスの流路に設けられ、前記両電極間の差圧に応じて開き前記オフガスの圧力を逃がすパージ弁と、を備えた燃料電池システムにおいて、前記他方のガスの圧力および弾性体の付勢力に基づく第1の推

力と前記一方のガスの圧力に基づく第2の推力とを互いに対向して作用させたときに生じる推力差に応じて弁開度調整を行い前記一方のガスを逃がして前記両電極間の差圧を調整する極間差圧調整弁を、前記レギュレータの下流に備えたことを特徴とする燃料電池システム。

【請求項2】 前記パージ弁の開弁閾値である両電極間の差圧は、前記差圧調整弁の開弁閾値である両電極間の差圧よりも小さく設定されていることを特徴とする請求項1に記載の燃料電池システム。

【請求項3】 前記パージ弁と前記極間差圧調整弁は一体に構成されており、一つの弁体が前記パージ弁の弁体と前記極間差圧調整弁の弁体を共有し、この弁体は、電氣的信号を駆動タイミングとする前記パージ弁の駆動部により開閉動作可能であるとともに、前記弁体に連係する隔壁であってその両側に前記第1の推力と前記第2の推力が対向して作用する隔壁を前記極間差圧調整弁の駆動部として弁開度調整可能であることを特徴とする請求項1または請求項2に記載の燃料電池システム。



## 詳細な説明

### 【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、固体高分子電解質膜型の燃料電池における極間差圧制御技術に関するものである。

【0002】

【従来の技術】燃料電池自動車等に搭載される燃料電池には、固体高分子電解質膜の両側にアノード電極とカソード電極とを備え、アノード電極に燃料ガス（例えば水素ガス）を供給し、カソード電極に酸化剤ガス（例えば酸素あるいは空気）を供給して、これらガスの酸化還元反応にかかる化学エネルギーを直接電気エネルギーとして抽出するようにしたものがある。この燃料電池では、アノード側で水素ガスがイオン化して固体高分子電解質中を移動し、電子は、外部負荷を通過してカソード側に移動し、酸素と反応して水を生成する一連の電気化学反応による電気エネルギーを取り出すことができるようになっている。

【0003】この燃料電池を備えた従来の燃料電池システムの一例を図5に示す。この燃料電池システムでは、酸化剤ガスとしての空気をコンプレッサ52により所定圧力に昇圧し、カソード加湿器53で加湿して燃料電池51のカソード電極に供給する。この空気は発電に供された後、燃料電池1から空気オフガスとして排出され、圧力制御弁54を介して排出される。この圧力制御弁54はカソード電極での空気の供給圧を制御する。一方、燃料ガスとしての水素ガスをレギュレータ55で減圧し、エゼクタ56を経由して、アノード加湿器57で加湿し、燃料電池1のアノード電極に供給する。ここで、レギュレータ55は、カソード電極に供給される空気の圧力に応じて、アノード電極に供給される水素ガスの圧力を減少させる。水素ガスは発電に供された後、燃料電池1から水素オフガスとして排出され、水素オフガス回収路61を通過してエゼクタに吸引され、レギュレータを通過した新鮮な水素ガスと合流して再び燃料電池1のアノード電極に供給される。

【0004】ところで、この燃料電池システムでは、固体高分子電解質膜の破損を回避するために、アノード電極の水素ガスの圧力とカソード電極の空気の圧力との差圧を所定の規定値以下に抑えて運転する必要がある。そこで、従来は、水素オフガス回収路61に電磁駆動式のパージ弁58を設け、前記差圧が前記規定値に達したときにパージ弁58を開弁させるようにパージ弁58を電気的に制御していた。特開平7-78624号公報にもこれと同様の技術が開示されている。なお、パージ弁58は、前記差圧制御のために開弁されるだけでなく、水素オフガス中に含まれる水分が凝縮して生成される凝縮水を排水するときなど、必要に応じて適宜開弁されるものである。

【0005】

【発明が解決しようとする課題】しかしながら、従来のようにパージ弁58の開閉を電気的に制御して前記両極間の差圧を制御した場合には、電気信号線の破断や電力の低下により、あるいはコンピュータ上で不具合が生じた場合には、パージ弁58が作動しなくなったり、不必要な開弁を行ってシステム効率を低下させる虞がある。

【0006】また、前記パージ弁を用いた極間差圧管理に代えて、バネ式ポップオフ弁を用いた最大圧力管理により機械的に過大圧力を逃がすことも考えられる。ここで、バネ式ポップオフ弁は、最大規定圧力値で開弁するようにバネ荷重を予め設定しておき、圧力が規定値を超えるとバネ荷重により閉弁状態に押さえられていた弁体が開弁して圧力を逃がす構造を有する機械式の逃がし弁である。このバネ式ポップオフ弁は開弁閾値である最大規定圧力をどこか1点の圧力値（一定圧）にしか設定できない。

【0007】しかしながら、燃料電池の場合には、図6に示すように、燃料電池の出力値に応じてアノード電極の上限圧が変化する。したがって、開弁閾値（最大規定圧力値）を一点しか設定できないバネ式ポップオフ弁で、燃料電池のアノード電極の最大圧力を管理するのは困難であり、実質的に不可能である。そこで、この発明は、燃料電池の出力値に応じて反応ガスの上限圧力が変化しても極間差圧の管理を確実に行うことができ、固体高分子電解質膜の破損防止をより確実にできる燃料電池システムを提供するものである。

【0008】

【課題を解決するための手段】上記課題を解決するために、請求項1に記載した発明は、固体高分子電解質膜の両側にアノード電極とカソード電極を有し、アノード電極に燃料ガス（例えば、後述する実施の形態における水素ガス）が供給されカソード電極に酸化剤ガス（例えば、後述する実施の形態における空気）が供給されて発電する燃料電池（例えば、後述する実施の形態における燃料電池1）と、前記燃料電池に供給される前記燃料ガスと酸化剤ガスのいずれか一方のガス（例えば、後述する実施の形態における水素ガス）の圧力を他方のガス（例えば、後述する実施の形態における空気）の圧力に応じて減少させるレギュレータ（例えば、後述する実施の形態におけるレギュレータ5）と、前記燃料電池から排出される前記一方のガスのオフガスの流路（例えば、後述する実施の形態における水素オフガス回収路11）に設けられ、前記両電極間の差圧に応じて開き前記オフガスの圧力を逃がすパージ弁（例えば、後述する実施の形態におけるパージ弁8）と、を備えた燃料電池システムにおいて、前記他方のガスの圧力および弾性体（例えば、後述する実施の形態におけるバイアス設定用スプリング29）の付勢力に基づく第1の推力と前記一方のガスの圧力に基づく第2の推力とを互いに対向して作用させたときに生じる推力差に応じて弁開度調整を行い前記一方のガスを逃がして前記両電極間の差圧を調整する極間差圧調整弁（例えば、後述する実施の形態における極間差圧調整弁20）を、前記レギュレータの下流に備えたことを特徴とする。

【0009】このように構成することにより、アノード電極に供給される燃料ガスの圧力あるいはカソード電極に供給される酸化剤ガスの圧力が燃料電池の出力に応じて変化しても、両電極間の差圧（以下、極間差圧という）をパージ弁と極間差圧調整弁のいずれかあるいは両方で制御することができる。特に、極間差圧調整弁では、前記一方のガスの圧力と他方のガスの圧力との差圧が大きいほど前記推力差も大きくなり、極間差圧調整弁は、前記推力差が大きいほど弁開度を大きくするように調整して極間差圧を小さくし、前記推力差が小さいほど弁開度を小さくするように調整して極間差圧を大きくする。その結果、極間差圧調整弁は、極間差圧を所定範囲に調整することが可能になる。また、極間差圧調整弁の作動は純粋に機械式であるので、システムに電気的なトラブルが生じた時にも正常に作動する。

【0010】請求項2に記載した発明は、請求項1に記載の発明において、前記パージ弁の開弁閾値である両電極間の差圧は、前記差圧調整弁の開弁閾値である両電極間の差圧よりも小さく設定されていることを特徴とする。このように構成することにより、正常運転時の極間差圧の管理は開弁閾値が小さいパージ弁の作動により実行し、極間差

圧が極間差圧調整弁の開弁閾値よりも大となったときには、パージ弁と極間差圧調整弁の両方が開弁して極間差圧をより迅速に低下させる。また、万が一、パージ弁が作動不良を起こした時にも、極間差圧調整弁が作動して固体高分子電解質膜の破損を防止する。

【0011】請求3項に記載した発明は、請求項1または請求項2に記載の発明において、前記パージ弁と前記極間差圧調整弁は一体に構成されており、一つの弁体(例えば、後述する実施の形態における弁体27)が前記パージ弁の弁体と前記極間差圧調整弁の弁体を共有し、この弁体は、電気的信号を駆動タイミングとする前記パージ弁の駆動部(例えば、後述する実施の形態におけるプランジャ35、ソレノイド用コイル37)により開閉動作可能であるとともに、前記弁体に連係する隔壁であってその両側に前記第1の推力と前記第2の推力が対向して作用する隔壁(例えば、後述する実施の形態における調圧ダイヤフラム22)を前記極間差圧調整弁の駆動部として弁開度調整可能であることを特徴とする。このように構成することにより、部品点数の減少、設置スペースの減少を図ることができる。

【0012】

【発明の実施の形態】以下、この発明に係る燃料電池システムの実施の形態を図1から図4の図面を参照して説明する。なお、以下の各実施の形態における燃料電池システムは燃料電池自動車に搭載された態様である。

【0013】〔第1の実施の形態〕初めに、この発明に係る燃料電池システムの第1の実施の形態を図1から図3の図面を参照して説明する。図1は燃料電池システムの概略構成図である。燃料電池1は、固体高分子電解質膜の両側にアノード電極とカソード電極が設けられ各電極の外側に反応ガスを供給するためのガス通路が設けられてなるセルを多数積層して構成されている。この燃料電池1は、アノード電極に燃料ガスとしての水素ガスが供給され、カソード電極に酸化剤ガスとしての空気が供給されて発電を行う。

【0014】空気はエアコンプレッサ2によって加圧され、カソード加湿器3で加湿されて燃料電池1のカソード電極に供給され、この空気中の酸素が酸化剤として供給された後、燃料電池1から空気オフガスとして排出され、圧力制御弁4を介して大気へ放出される。ECU10は、燃料電池1に要求されている出力(以下、要求出力)に応じて、エアコンプレッサ2を駆動して所定量の空気を燃料電池1に供給するとともに、圧力制御弁4を制御してカソード電極での空気の供給圧を燃料電池1の要求出力に応じた圧力に調整する。

【0015】一方、図示しない高圧水素タンクから放出された水素ガスはレギュレータ5により減圧された後、エゼクタ6を通り、アノード加湿器7で加湿されて燃料電池1のアノード電極に供給される。この水素ガスは発電に供給された後、燃料電池1から水素オフガスとして排出され、水素オフガス回収路11を通してエゼクタ6に吸引され、前記高圧水素タンクから供給される水素ガスと合流し再び燃料電池1に供給され循環するようになっている。

【0016】レギュレータ5は、例えば空気式の比例圧力制御弁からなり、エアコンプレッサ2から供給される空気の圧力を信号圧として空気信号導入路15を介して入力され、レギュレータ5出口の水素ガスの圧力が前記信号圧に応じた所定圧力範囲となるように減圧制御する。なお、この実施の形態における燃料電池システムでは、レギュレータ5は、アノード電極に供給される水素ガスの圧力(以下、「アノード極ガス圧」と称す)がカソード電極に供給される空気の圧力(以下、「カソード極ガス圧」と称す)よりも大きくなるように制御する。

【0017】水素オフガス回収路11は電磁駆動式のパージ弁8を介して水素オフガス排出路12に接続されている。ECU10は、アノード極ガス圧とカソード極ガス圧との差圧、すなわち極間差圧を検出する差圧センサ9の出力に基づいて、パージ弁8の電磁駆動部を作動して開閉制御を行う。すなわち、パージ弁8の電磁駆動部は電気的信号を駆動タイミングとしている。このパージ弁8は、差圧センサ9の出力値が $\Delta P1$ に達したときに開弁して極間差圧を $\Delta P1$ 以下に制御するほか、所定の条件が満たされたときに開弁して、燃料電池1のアノード電極側に水が溜まらないように排水するなどの作用がある。

【0018】エゼクタ6とアノード加湿器7を接続する水素供給路13は、本発明の特徴的な構成を有する極間差圧調整弁20を備えた水素ガス排出路14を介して水素オフガス排出路12に接続されている。この極間差圧調整弁20について図2の概略断面図を参照して説明する。極間差圧調整弁20のボディ21の内部空間は調圧ダイヤフラム22によって上下に仕切られていて、ダイヤフラム22よりも上側の空間は信号圧室23になっていて、下側の空間は水素ガス通路24になっている。信号圧室23は空気導入孔25を備えた密閉空間になっていて、コンプレッサ2で加圧された空気が空気信号導入路15を介して空気導入孔25から信号圧室23に導入される。

【0019】ダイヤフラム22の下面にはステム26が取り付けられており、ステム26には、水素ガス通路24内のバルブシート部28に対して上側から着座離反可能な弁体27が設けられている。そして、信号圧室23には、弁体27をバルブシート部28に着座する方向に付勢するバイアス設定用スプリング(弾性体)29が設けられている。

【0020】また、ボディ21には、弁体27が配置されている側の水素ガス通路24aに連通する水素ガス入口31と、弁体27が配置されていない側の水素ガス通路24bに連通する水素ガス出口32が設けられていて、水素ガス入口31は水素ガス排出路14を介して水素供給管13に接続され、水素ガス出口32は水素ガス排出路14を介して水素オフガス排出路12に接続されている。したがって、図1および図2に示すように、エゼクタ6で減圧された水素ガスが水素ガス入口31から水素ガス通路24aに導入され、弁体27がバルブシート部28から離間して開弁すると、水素ガス通路24aに導入された水素ガスは水素ガス通路24bに流出し、さらに水素ガス出口32から水素オフガス排出路12へと流れるようになる。

【0021】なお、極間差圧調整弁20を構成する部品のうち水素ガスに触れる部品については水素に対する耐食性に優れたものを使用するのが好ましく、例えば、ボディ21、弁体27、ステム26にはステンレスあるいは表面アルマイト処理を施したアルミニウムなどが好適であり、ダイヤフラム22にはフッ素ゴムが好適である。

【0022】このように構成された極間差圧調整弁20では、信号圧室23内の空気の圧力とスプリング29の付勢力がダイヤフラム22の上面に作用する結果、これらに基づく第1の推力がダイヤフラム22の上面に下向きに作用し、一方、水素ガス通路24a内の水素ガスの圧力がダイヤフラム22の下面に作用する結果、これに基づく第2の推力がダイヤフラム22の下面に上向きに作用する。そして、ダイヤフラム22はこれら第1の推力と第2の推力の推力差に支配されて動くこととなる。すなわち、第2の推力が第1の推力よりも小さいときにはダイヤフラム22に下向きの力が作用し、弁体27をバルブシート部28に接近させる方向(すなわち、閉弁方向)へ押動し、第2の推力が第1の推力よりも大きくなったときにはダイヤフラム22に上向きの力が作用し、弁体27をバルブシート部28から離間させる方向(すなわち、開弁方向)へ押動する。

【0023】ところで、信号圧室23に供給される空気の圧力はカソード極ガス圧とほぼ同圧であり、水素ガス通路24aに供給される水素ガスの圧力はアノード極ガス圧とほぼ同圧である。したがって、極間差圧調整弁20は、カソード極

ガス圧およびスプリング29の付勢力に基づく第1の推力とアノード極ガス圧に基づく第2の推力とをダイヤフラム22を挟んで対向して作用させたときに生じる推力差に応じて弁開度調整を行う調整弁と行うことができる。

【0024】そして、この実施の形態の極間差圧調整弁10においては、閉弁状態でスプリング29が圧縮されているように設定し(換言すれば、閉弁状態においてスプリング29の付勢力がダイヤフラム22に作用するように設定し)、且つ、閉弁状態におけるスプリング29の付勢力に対応する圧力を極間差圧の上限値 $P_{lim}$ に設定する。このように設定すると、極間差圧が $P_{lim}$ 以下のときには第1の推力が第2の推力よりも大となるので、弁体27がバルブシート部28に着座した閉弁状態を保持し、極間差圧が上限値 $P_{lim}$ を越えたときには第2の推力が第1の推力よりも大となるので、弁体27がバルブシート部28から離間して開弁し、水素ガス通路24a内の水素ガスを水素オフガス排出路12へと逃がして、極間差圧を減少させるように作用する。そして、極間差圧の減少とともに弁体27が閉弁方向に動き、極間差圧が上限値 $P_{lim}$ 以下になると弁体27がバルブシート部28に着座して閉弁する。なお、閉弁状態におけるスプリング29の付勢力 $F$ 、極間差圧の上限値 $P_{lim}$ 、ダイヤフラム22の面積 $S$ との間には、次式が成立する。

$F = P_{lim} \cdot S$ 【0025】また、この実施の形態においては、ページ弁8の開弁閾値である差圧値 $\Delta P_1$ を、極間差圧調整弁20の開弁閾値である上限値 $P_{lim}$ よりも小さく設定する。このようにすると、正常運転時においては開弁閾値が小さいページ弁8により極間差圧の管理が行われ、燃料電池1を良好な運転状態に維持することができる。そして、極間差圧が極間差圧調整弁20の開弁閾値よりも大となったときには、ページ弁8に加え極間差圧調整弁20の両方が開弁して極間差圧を迅速に低下させ、固体高分子電解質膜の破損を確実に防止することができる。

【0026】さらに、極間差圧調整弁20は純粋に機械的に作動するので、万が一、システム上の電気的なトラブル(例えば、ページ弁8に対する電気信号線の破断や電力低下、コンピュータ上のトラブル等)などによりページ弁8が作動不良を起こした時にも、極間差圧調整弁20は確実に作動して固体高分子電解質膜の破損を防止し、フェールセーフの点で極めて優れている。また、この燃料電池システムにおける圧力管理は、開弁閾値を1点しか設定できないバネ式ポップオフ弁を用いてアノード極ガス圧の最大圧力を管理するのではなく、ページ弁8と極間差圧調整弁20のいずれかあるいは両方によって極間差圧を管理しているので、アノード極ガス圧あるいはカソード極ガス圧が燃料電池1の出力に応じて変化しても、極間差圧を管理する上では殆ど影響がなく、したがって、固体高分子電解質膜の破損を確実に防止することができる。

【0027】図3は極間差圧調整弁20の設置位置を変更した変形例である。すなわち、図3の例では、水素オフガス回収路11と水素オフガス排出路12とを接続する水素オフガス排出路16に極間差圧調整弁20を設けている。そして、水素オフガス回収路11を流れる水素オフガスが水素オフガス路16を介して図2の極間差圧調整弁20の水素ガス入口31から水素ガス通路24aに導入される。さらに、コンプレッサ2で加圧された空気が空気信号導入路17を介して空気導入孔25から信号圧室23に導入される。このように設置した極間差圧調整弁20によっても、極間差圧が $P_{lim}$ を越えた場合に極間差圧調整弁20が開弁して極間差圧を減少させることができ、図1の態様のものと同様の作用・効果を得ることができる。

【0028】[第2の実施の形態]図4はページ弁8と極間差圧調整弁20とを一体化した例を示している。なお、ここでは一体化された弁全体を便宜上、極間差圧調整弁20と呼ぶこととする。この極間差圧調整弁20の場合にも、ボディ21と、調圧ダイヤフラム(隔壁)22と、信号圧室23と、水素ガス通路24、24a、24bと、空気導入孔25と、ステム26と、弁体27と、バルブシート部28と、バイアス設定用スプリング29と、水素ガス入口31と、水素ガス出口32を備えている。弁体27は、ページ弁の弁体であるとともに極間差圧調整弁の弁体でもあり、したがって、弁体27を共有している。この極間差圧調整弁20では、ステム26がダイヤフラム22の上側にも延びていて、ステム26の上端にページ弁用のプランジャ(ページ弁の駆動部)35が設けられており、ボディ21にはプランジャ35を上下動可能に収納するプランジャ収納部36が設けられており、プランジャ収納部36の外側にプランジャ35を昇降動させるためのソレノイド用コイル(ページ弁の駆動部)37が設けられている。

【0029】この極間差圧調整弁20を前述したページ弁8として機能させるときには、ソレノイド用コイルに電流を流して電磁石とし、プランジャ35をスプリング29の付勢力に抗して上方に引き上げることにより、弁体27をバルブシート部28から離間させ開弁する。すなわち、ページ弁としての弁体27は、電気的信号を駆動タイミングとする駆動部(プランジャ35、ソレノイド用コイル37)によって開閉動作される。

【0030】また、ステム26を介して弁体27に連係する隔壁22には、信号圧室23内の空気の圧力およびスプリング29の付勢力に基づく第1の推力と、水素ガス通路24a内の水素ガスの圧力に基づく第2の推力が、対向して作用しており、この隔壁22は弁体27の弁開度調整を行う駆動部(極間差圧調整弁の駆動部)としての機能を有している。すなわち、何らかの電気的トラブル(例えば、電気信号線の破断や電力低下等)などによりページ弁としての正常な作動が行われない事態が生じて、極間差圧が上限値 $P_{lim}$ を越えたときには、前記第2の推力が前記第1の推力よりも大となるので、弁体27がバルブシート部28から離間して開弁し、水素ガス通路24a内の水素ガスを水素オフガス排出路12へと逃がして、極間差圧を減少させるように作用する。そして、極間差圧の減少とともに弁体27が閉弁方向に動き、極間差圧が上限値 $P_{lim}$ 以下になると弁体27がバルブシート部28に着座して閉弁する。

【0031】このように、ページ弁と極間差圧調整弁を一体化すると、システムの構成部品を一つ減らすことができ、専有空間を減らすことができるので、設置スペースに限りがある車両搭載用の燃料電池システムでは非常に有利になる。

【0032】[他の実施の形態]尚、この発明は前述した実施の形態に限られるものではない。例えば、前述した実施の形態は、アノード極ガス圧をカソード極ガス圧よりも大きく制御する燃料電池システムにおける極間差圧調整に極間差圧調整弁を用いているが、カソード極ガス圧をアノード極ガス圧よりも大きく制御する燃料電池システムにおける極間差圧調整に極間差圧調整弁20を用いることも可能である。

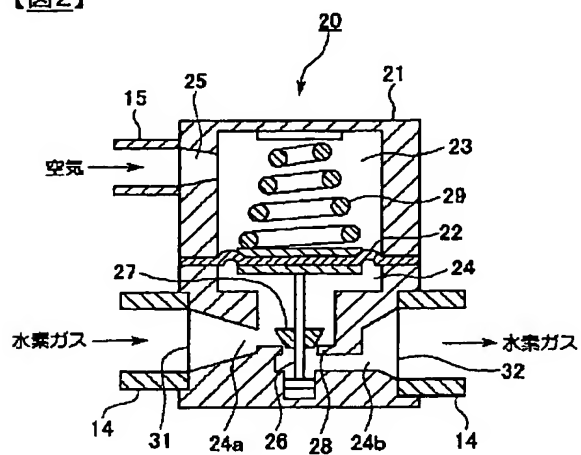
【0033】

【発明の効果】以上説明するように、請求項1に記載した発明によれば、アノード電極に供給される燃料ガスの圧力あるいはカソード電極に供給される酸化剤ガスの圧力が燃料電池の出力に応じて変化しても、極間差圧をページ弁と極間差圧調整弁のいずれかあるいは両方で制御することができるので、システム効率を低下させることなく燃料電池の良好な運転状態を確実に維持できるとともに、固体高分子電解質膜の破損を確実に防止することができるという優れた効果が奏される。特に、極間差圧調整弁は、純粋に機械的な作動により極間差圧を所望の範囲に調整するので、システムに電気的なトラブルが生じた時にも正常に作動し、フェールセーフの点でも極めて優れている。

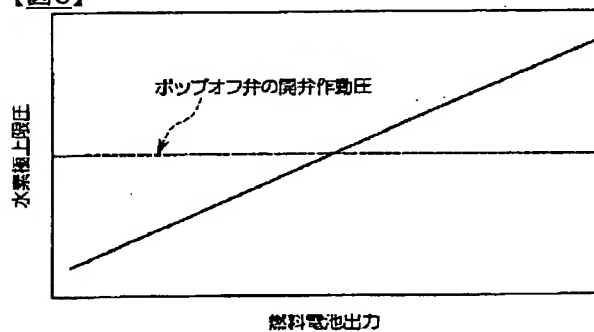
【0034】請求項2に記載した発明によれば、正常運転時の極間差圧の管理は開弁閾値が小さいパージ弁の作動により実行することができ、極間差圧が極間差圧調整弁の開弁閾値よりも大となったときには、パージ弁と極間差圧調整弁の両方が開弁して極間差圧を迅速に低下させるので、固体高分子電解質膜の破損を確実に防止することができる。また、万が一、パージ弁が作動不良を起こした場合も、極間差圧調整弁が作動して固体高分子電解質膜の破損を確実に防止するので、フェールセーフの点でも極めて優れている。請求項3に記載した発明によれば、部品点数の減少、設置スペースの減少を図ることができるという効果がある。

## 図面

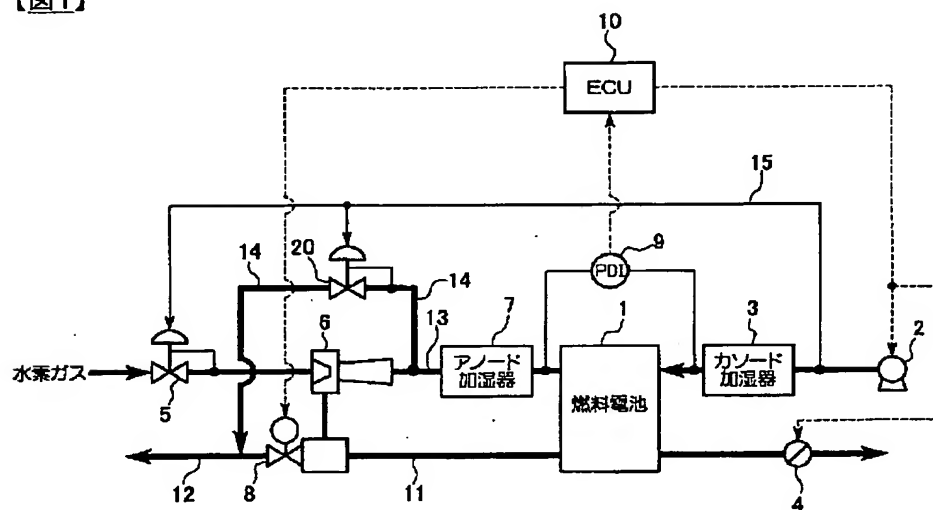
【図2】



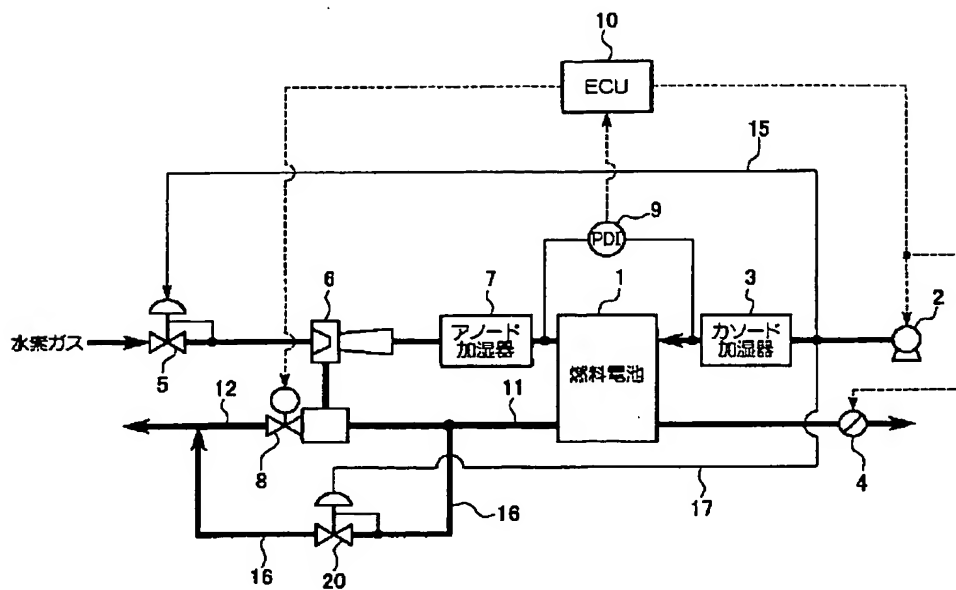
【図6】



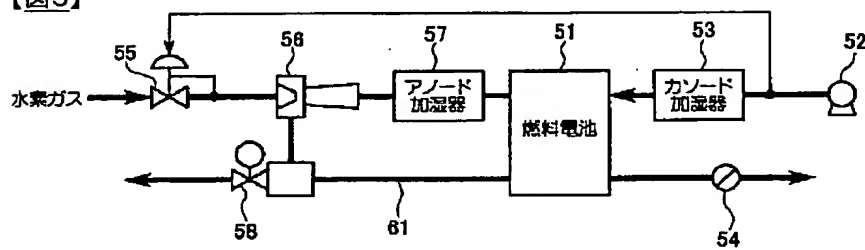
【図1】



【図3】



【図5】



【図4】

